

EFFECT OF HEAT TREATMENT ON THE ANTIOXIDANT ACTIVITIES OF TWO CULTIVARS OF SWEET POTATOES

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Abstract

Natural sources of antioxidants are derived from fruits, vegetables and wine, whilst artificial supplements are from teas and spices. Sweet potato (*Ipomoea batatas*) is an excellent natural source of vitamins and minerals, and likely a great source of antioxidant. The objective of this study is to analyze the antioxidant activity of orange sweet potato (Vitato) and purple sweet potato (All purple), prepared as heat dry and moist heat for 30 minutes at 100°C. All the samples were obtained from Pasir Puteh and MARDI Telong, Bachok, Kelantan, respectively. Both samples were soaked into methanol to obtain the crude extract prior to analyzing for antioxidant activity by using 2, 2-diphenyl-1-picryl hydrazyl (DPPH). IC₅₀ values of dry heat and moist heat Vitato were 0.40mg/L and 0.20mg/L while dry heat and moist heat, All purple were 0.32mg/L and 0.19mg/L, respectively. Both moist heat samples enjoyed higher scavenging activities compared to dry heat samples. However, the All purple sample of moist heat is the most superior one. Significant difference of IC₅₀ values between dry heat and moist heat sample differ significantly. Thus, this study clearly demonstrated that moist heat sweet potato exhibited excellent increase in antioxidant activity.

Keywords: Antioxidant activity, two sweet potato cultivars, moist heat, heat dry

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1.0 INTRODUCTION

Free-radical scavengers or antioxidant products are in demand as consumers are aware of the power that this compound exhibit in stabilizing the free radicals in our body. Antioxidant extracts from sweet potatoes have been observed to slow down degenerative diseases and even cancer related

cells. The presence of considerable amounts of beta-carotene and anthocyanin in sweet potatoes will act as free radical scavengers. Sweet potatoes are also considered as rich source of nutrients, essential elements and vitamins required for healthy diet and wellbeing.¹ In Malaysia, sweet potatoes are usually cooked in many different ways: either steamed, fried, or roasted before consumption. These practices will

possibly affect the nutritional composition as well as influence its antioxidant properties. These domestic cooking practices could either be detrimental or beneficial to food nutrients content as well as its antioxidant capability.²⁻⁴ This phenomenon will be further discussed in this paper.

2.0 MATERIALS & METHODS

2.1 Study Sites

The sites were chosen based on the availability of the samples and must be on BRIS derived soils (Beach Ridges Interspersed with Swales). One chosen site was located at Pasir Putih, Kelantan and the other at MARDI Research Station in Telong, Bachok, Kelantan, off the east coast of Peninsular Malaysia. These two sites are approximately 18 km apart. BRIS soil originates from sediment or sand from the sea that accumulated due to tidal movement and erosion process.⁷ According to the Ministry of Agriculture of Malaysia,⁸ this soil belongs to the order Spodosols. The topsoil texture is dominated by 97-98% sand fraction, with less than 1% clay fraction. This soil is highly nutrient deficient, too sandy, weakly structured, low water retention capability and acidic in nature.⁹⁻¹⁰

2.2 Sample Collection and Preparation

Two sweet potato cultivars comprising of orange-fleshed sweet potato (Vitato) and purple fleshed potato (All purple) were randomly collected from Pasir Putih, Kelantan and MARDI Telong, Bachok, Kelantan, respectively. Both samples were dry heat and moist heat, peeled and sliced into 0.5cm to 0.8cm thickness. As for moist heat sweet potato, samples were steamed for 30 minutes using a steamer set at 100°C. All samples were oven dried at 50°C for 2 days, ground into fine pieces and stored in Ziploc® bags at room temperature for further analysis.

2.3 Extraction Preparation

30g of powdered samples were soaked into 90mL methanol for 2 days. The mixtures were filtered using Whatman No.1 filter paper to obtain crude methanol extract. The extract was concentrated under vacuum on rotary evaporator (Hei-Vap Precision ML G3B), stored in universal bottle and left in fume board for methanol to fully evaporate.

2.4 Antioxidant Activity

Antioxidant activity was analyzed by using method modified by Steed & Truong.¹¹ 1mL of 0.004% DPPH in methanol was pipetted into different concentration (1.0, 0.5, 0.25, 0.125 and 0.0625mg/L) of standard extract ascorbic acid. The absorbance was read at 517nm with Thermo Scientific, Genesys 20

spectrophotometer after being subjected to incubation in the dark for 30 minutes. The absorbance of standards and samples were measured against DPPH control, which consisted of DPPH and methanol. Inhibition curves were prepared and IC₅₀ values were obtained. Percentage of inhibition was calculated by using:

$$DPPH\ Scavenging\ (\%) = \left[1 - \left(\frac{A_{sample}}{A_{control}} \right) \right] \times 100$$

3.0 RESULTS

Based on Table 1, it is interesting to note that the scavenging activity increases with all the cultivars tested. However, the significant ones are the moist heat samples for both cultivars. We noted that the most significant is the All purple cultivar. The different samples concentration and percentage of radical scavenging activities within the same concentration are shown in Table 2 and Figure 1. Maximum radical scavenging activities for dry heat and moist heat Vitato were 76.32% and 77.53%, respectively. Whilst for dry heat and moist heat All purple samples, the maximum radical scavenging activities were 77% and 76.09%, respectively, which maximized at 1.0mg/L concentration. Using IC₅₀ as a standard value, the optimum antioxidant activity is achieved by moist heat All purple, closely followed by moist heat Vitato. Next comes the dry heat sample of All purple and finally the dry heat Vitato (Figure 1). In this study, ascorbic acid served as a control, where the increased trend of its antioxidant activity can be observed in Table 1 and Figure 1, and the maximum scavenging activity was noted at 81.34% of 1.0mg/L concentration level. Significant scavenging activities were noted for moist heat samples for both cultivars in all concentrations used, except the lower end and the upper end and they dominated the scavenging activities in comparison to dry heat samples (Table 2 and Figure 2).

Table 1 Comparison between different concentrations on the same cultivars of sweet potatoes

		Scavenging activity (%) ± SD				
Cultivars/ Treatment	Concentration (mg/L)	0.0625	0.125	0.25	0.50	1.00
Vitato Raw		4.77 ±0.35 ^c	17.44 ±1.94 ^d	32.81 ±1.45 ^c	57.39 ±1.38 ^c	76.32 ±1.68 ^a
Moist		6.73	34.60	57.27	66.34	77.53
Dry		±0.44 ^b	±1.30 ^b	±1.13 ^a	±1.36 ^a	±1.32 ^a
All Purple		12.55	27.36	42.99	63.47	77.00
Raw		±0.89 ^a	±1.39 ^c	±1.66 ^b	±1.9 ^b	±1.36 ^a
Moist Dry		7.43	37.02	58.22	66.46	76.09
		±0.66 ^b	±1.27 ^a	±1.67 ^a	±1.27 ^a	±1.84 ^a

a,b,c,d different letters in the same row differed significantly at (p < 0.05)

Table 2 Comparison within different sweet potato cultivars on the same concentration, with ascorbic acid as the control.

Treatment	Scavenging Activity (%) \pm SD					IC ₅₀ (mg/L)
	0.0625 mg/L	0.125 mg/L	0.25 mg/L	0.5 mg/L	1.0 mg/L	
Vitato						
Dry heat	4.77 \pm 0.35 ^a	17.44 \pm 1.94 ^b	32.81 \pm 1.45 ^c	57.39 \pm 1.38 ^d	76.32 \pm 1.68 ^e	0.4
Moist heat	6.73 \pm 0.44 ^a	34.60 \pm 1.30 ^b	57.27 \pm 1.13 ^c	66.34 \pm 1.36 ^d	77.53 \pm 1.32 ^e	0.2
All Purple						
Dry heat	12.55 \pm 0.89 ^a	27.36 \pm 1.39 ^b	42.99 \pm 1.66 ^c	63.47 \pm 1.9 ^d	77.00 \pm 1.36 ^e	0.32
Moist heat	7.43 \pm 0.66 ^a	37.02 \pm 1.27 ^b	58.22 \pm 1.67 ^c	66.46 \pm 1.27 ^d	76.09 \pm 1.84 ^e	0.19
Ascorbic Acid	75.20 \pm 0.36	76.70 \pm 0.43	78.51 \pm 0.38	80.30 \pm 0.34	81.34 \pm 0.50	0.02

a,b,c,d different letters in the same row differed significantly at ($p < 0.05$)

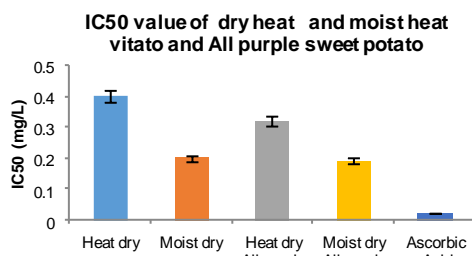


Figure 1 Comparison of antioxidant activity at different concentration and treatment, with ascorbic acid as a control

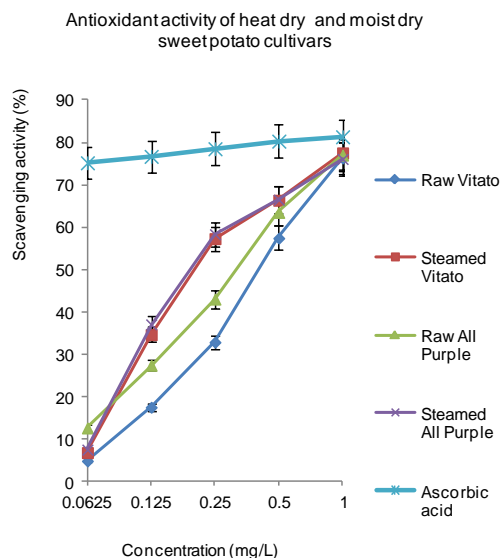


Figure 2 IC₅₀ value of Raw and Steamed Vitato and All purple Sweet Potato, with ascorbic acid as a control and moist dry All purple showing the highest scavenging activity

4.0 DISCUSSION

Sweet potato is rich in vitamin B6 and is capable of breaking down the homocystein and maintain smooth blood passageways in blood vessels and thus preventing heart attack.¹²⁻¹³ The orange cultivar Vitato is rich in carotenoid pigments, an effective source of vitamin A, known to improve failing eyesight and boosting the body's immune system. All purple sweet potato contains high amounts of anthocyanin, a secondary metabolite and a powerful antioxidant.¹⁴⁻¹⁵ Furthermore, both cultivars and their leaves are antioxidant rich due the presence of carotene, anthocyanin, phenolic acid and other flavonoids.¹⁶⁻¹⁸

Based on Table 1, all the cultivars treatments showed positive increment in scavenging activities with increasing concentrations. This is already a positive indication of the presence of antioxidant compounds as acknowledged by the referred journals.¹⁹⁻²² However, significant increment were noted in moist heat samples of both cultivars, but dominating amounts recorded in All purple moist heat samples (Table 1, Table 2, Figure 1 and Figure 2). This results clearly indicates that moist heat sweet potatoes have higher ability in reducing free radical than in dry heat form. It is interesting to note that highest scavenging activity is recorded in moist heat All purple cultivars. This observed phenomenon is possibly due to higher levels of anthocyanin, a powerful antioxidant of flavonoid phytochemical group.²³⁻²⁷ This same colour pigment (anthocyanin) is widely use in the medical field, for example, bilberry for diarrhea, coronary heart disease, antiviral and microbial infections and vision disorders.²⁸ Heat treatment such as oven drying, microwave heating and steaming had significantly increased the amounts of antioxidants in green beans, pepper, broccoli and spinach.²⁹ The process of steaming and oven drying of sweet potatoes for a period of 30 minutes is believed to yield higher levels of antioxidants.^{9, 30} Heating process is believed to suppress the thermal inactivation of oxidative enzymes such as polyphenoloxidase, peroxidase and glycosidase in order to sustain the beta-carotene and anthocyanin content in the sweet potato.³¹⁻³²

IC₅₀ refers to half maximal inhibitory concentration which is used to illustrate and determine the concentration of sweet potato required to scavenge 50% of the free radicals. In other words, the lower the value of IC₅₀, the better it serves as radical scavenger. Ascorbic acid is used as standard reference antioxidant, as well as to validate the results obtained since previous study showed that IC₅₀ value of ascorbic acid is within the range of 0.0001-0.10 mg/L.³³ The IC₅₀ value achieved in this study is 0.02 mg/L, which is within the above range. The moist heat All purple recorded the highest scavenging activity value of 0.19 mg/L, followed closely by moist heat Vitato, 0.20 mg/L, dry heat All purple at 0.32 mg/L and dry heat Vitato at 0.40 mg/L,

indicating the diminishing amounts of anthocyanin and carotenoid content.

5.0 CONCLUSION

Destruction of cell wall and subcellular compartments through heat treatments may possibly enhance the phytochemical constituents, thus increasing the antioxidant activity as exhibited by All purple cultivar. High content of carotenoid and anthocyanin compound in sweet potatoes are the most probable explanation to this increment. However, further studies are suggested to isolate the bioactive compound using more varieties of sweet potatoes, including their leaves.

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References

- [1] United States Department of Agriculture. 2010. National Nutrient Database for Standard Reference Release 27. USDA Research Service. Retrieved from: <http://ndb.nal.usda.gov/> on January 2015.
- [2] Podsedek, A. 2007. Natural Antioxidants And Antioxidant Capacity Of Brassica Vegetables: A Review. *Lebensmittel-Wissenschaft und Technologies*. 40: 1-11.
- [3] Chukwu, O., Orhevba, B. A., & Mahmood, B. A. 2010. Influence Of Hydrothermal Treatments On Proximate Compositions Of Fermented Locust Bean (*Dawadawa*). *Journal of Food Technology*. 8(3): 99-101.
- [4] Tokusoglu, O., & Yildirim, Z. 2011. Effects Of Cooking Methods On The Anthocyanin Levels And Antioxidant Activity Of A Local Turkish Sweet Potato (*Ipomoea Batatas* (L.) Lam) Cultivar Hatay Kimizi: Boiling, Steaming And Frying Effects. *Turkish Journal Of Field crop*. 17(1): 87-90.
- [5] Blumenthal, M. M. 1991. A Look At The Chemistry And Physics Of Deep Fat Frying. *Food Technology*. 2: 68-74.
- [6] Bellail, A. A., Shaltout, O. E., Youssef, M. M., & El Gamal, A. M. M. 2012. Effect Of Home-Cooking Methods On Phenolic Composition And Antioxidant Activity Of Sweet Potato (*Ipomoea Batatas* (L.) Lam.) Cultivars Grown In Egypt. *Food and Nutrition Sciences*. 3(4): 490-499.
- [7] Nossin, J. J. 1964. Beach Ridges of the East Coast of Malaya. *Tropical Geography Journal*. 18: 111-117.
- [8] Ministry of Agriculture Malaysia. 1993. Guides to General Soil Series in Peninsular Malaysia. 80-84.
- [9] Amir, H. M. S., Suhaimi, W. C., Adzmi, Y., & Mohd. Ghazali H. 1992. Which Canopy Tier Should Be Sampled To Determine The Fertility (Nutritional) Status Of Acacia Mangium On Bris Soils? *Journal of Tropical Forest Science*. 6(1): 48-55
- [10] Marlia, M. H., Jumaat, A., Mohd Barzani G., Sahibin, R., Nurulhuda, E. M. 2004. Management and Conservation of Bris Soil for Agricultural in Marang, Terengganu. *Third Annual Seminar on Sustainability Science and Management*. 265-268.
- [11] Steed, L. E., & Truong, V. D. 2008. Anthocyanin Content, Antioxidant Activity And Selected Physical Properties Of Flowerable Purple-Fleshed Sweet Potato Purees. *Journal of Food Science*. 73(5).
- [12] Cook, M. S. 2011, November 15. 9 Health Benefits Of Sweet Potatoes. Retrieved from <http://www.care2.com/greenliving/9-reasons-to-love-sweet-potatoes.html>.
- [13] Norek, D. 2012, May 2. 5 Huge Health Benefits Of Sweet Potatoes. Retrieved from http://www.naturalnews.com/035739_sweet_potatoes_beta-carotene_nutrients.html.
- [14] Woolfe, J. 1993. *Sweet Potato: An Untapped Food Resource*. Cambridge: Cambridge University Press.
- [15] Harada, K., Kano, M., Takayanagi, T., Yamakawa, O., & Ishikawa, F. 2004. Absorption Of Acylated Anthocyanin In Rats And Humans After Ingesting An Extract Of *Ipomoea Batatas* Purple Sweet Potato Tuber. *Bioscience Biotechnology and Biochemistry*. 68: 1500-1507.
- [16] Walter, W. M., & Schadel, W. E. 1981. Distribution Of Phenols In Jewel Sweet Potato Roots (*Ipomoea batatas* (L.) Lam.). *Journal Agriculture Food Chemistry*. 29: 904-906.
- [17] Panda, V., & Sonkamble, M. 2012. Phytochemical Constituents And Pharmacological Activities Of *Ipomoea batatas* L. (Lam)-a Review. *International Journal Res Phytochemical Pharmacological*. 2(1): 25-34.
- [18] Islam, M. S., Yoshimoto, M., Yahara, S., Okuno, S., Ishiguro, K., & Yamakawa, O. 2002. Identification And Characterization Of Foliar Polyphenolic Composition In Sweet Potato (*Ipomoea batatas* L.) Genotypes. *Journal Agriculture Food Chemistry*. 50: 3718-3722.
- [19] Walter, W. M., & Schadel, W. E. 1981. Distribution Of Phenols In "Jewel" Sweet Potato (*Ipomoea batatas* (L.) Lam.) Roots. *Journal Agriculture Food Chemistry*. 29: 904-906.
- [20] Kahkonen, M. P., Hopia, A. I., Heikki, J., Vuorela, Rauha, J. P., Pihlaja, K., Kujala, T. S., & Heinonen, M. 1999. Antioxidant Activity Of Plant Extracts Containing Phenolic Compounds. *Journal Agriculture Food Chemistry*. 47(10): 3954-3962.
- [21] Islam, M. S., Yoshimoto, M., Yahara, S., Okuno, S., Ishiguro, K., & Yamakawa, O. 2002. Identification And Characterization Of Foliar Polyphenolic Composition In Sweet Potato (*Ipomoea batatas* L.) Genotypes. *Journal Agriculture Food Chemistry*. 50: 3718-3722.
- [22] Panda, V., & Sonkamble, M. 2012. Phytochemical Constituents And Pharmacological Activities Of *Ipomoea batatas* L. (Lam)-A Review. *International Journal Res Phytochemical Pharmacological*. 2(1): 25-34.
- [23] Oki, T., Suda, I., Terahara, N., Sato, M., & Hatakeyama, M. 2006. Determination Of Acylated Anthocyanins In Human Urine After Ingesting A Purple-Fleshed Sweet Potato Beverages With Various Contents Of Anthocyanin by LC-ESI-MS/MS. *Bioscience Biotechnology and Biochemistry*. 70: 2540-2543.
- [24] Lauro, G. J., & Francis, F. J. (Eds). 2000. *Natural Food Colours, Science And Technology*. IFTBasic Symposium Series 14, Marcel Dekker.
- [25] Tsukui, A., Murakami, T., Shiina, R., & Hayashi, K. 2002. Effect Of Alcoholic Fermentation On The Stability Of Purple Sweet Potato Anthocyanins. *Food Science and Technology Research*. 8: 4-7.
- [26] Suda, I., Oki, T., Masuda, M., Nishiba, Y., & Furuta, S. 2003. Physiological Functionality Of Purple-Fleshed Sweet Potatoes Containing Anthocyanins And Their Utilization In Foods. *Japan Agricultural Research Quarterly*. 37: 167-173.
- [27] Giusti, M. M., & Wrolstad, R. E. 2003. Acylated Anthocyanins From Edible Sources And Their Application In Food Systems. *Biochemical Engineering Journal*. 14: 217-225.
- [28] Wang, S., & Jiao, H. 2000. Scavenging Capacity Of Berry Crops On Superoxide Radicals, Hydrogen Peroxide, Hydroxyl Radicals And Singlet Oxygen. *Journal of Agricultural and Food Chemistry*. 48: 5677-5684.
- [29] Turkmen, N., Sari, F., & Velioglu, S. 2005. The Effect Of Cooking Methods On Total Phenolics And Antioxidant Activity Of Selected Green Vegetables. *Food Chemistry*. 93: 713-718.

- [30] Huang, D. J., Lin, C. D., Chen, H. J., & Lin Y. H. 2004. Antioxidant And Antiproliferative Activities Of Sweet Potato (*Ipomoea batatas* (L.) Lam "Training 5" constituents. *Botanical Bulletin of Academia Sinica*. 45: 179-186.
- [31] Yamaguchi, T., Mizobuchi, T., Kajikawa, R., Kawashima, H., Miyabe, F., & Terao, J. 2001. Radical Scavenging Activity Of Vegetables And The Effect Of Cooking On Their Activity. *Food Science and Technology Research*. 7(3): 250-257.
- [32] Wrolstad, R. E., Durst, R. W., & Lee, J. M. 2005. Tracking A Colour Pigment Changes In Anthocyanin Products. *Journal of Food Science and Technology*. 16: 423-428.
- [33] Abdullah, N. S., Muhamad, S., Omar, I. C., & Abdullah, H. 2013. Determination Of Antioxidant And Cytotoxic Activities Of Red Seaweed, (*Gracilaria Manillaensis*) Against Different Cancer Cell Lines. *Journal of Food Science and Engineering*. 3: 616-624.